Kailua Waterways Improvement Program
Waters of the Kailua Ahupua`a

This is an overview of the Kailua ahupua`a waterway system. It is intended as a summary of general concepts and terms and a presentation of general flow conditions within the Kailua ahupua`a.

Waterway System

The presence and flow of water in any system, whether in the tropics, arctic, or desert climates, are based on a continuous cycle of water movement from reservoirs to the air and back to the reservoirs again. The continuous water cycle is composed of the following elements:

Evaporation:	Water evaporating from reservoirs to air
Transpiration:	Water released from plants to air
Condensation:	Water in air liquefied to form fog or clouds
Precipitation:	Rain or dew from fog or clouds
Overland flow:	Rainwater moving
Infiltration:	Water percolating through the ground

Each component of the water cycle plays an important role in maintaining the natural balance in an ecosystem. For example, during drought conditions, evaporation increases and therefore water in streams, lakes, or groundwater will decrease, thereby changing plant conditions and natural drainage. Changes in native plant populations in forested areas can affect water uptake, potentially increasing surface runoff, sedimentation in streams and ponds, and ultimately erosion of hillsides. A typical water cycle is shown on Figure 1.

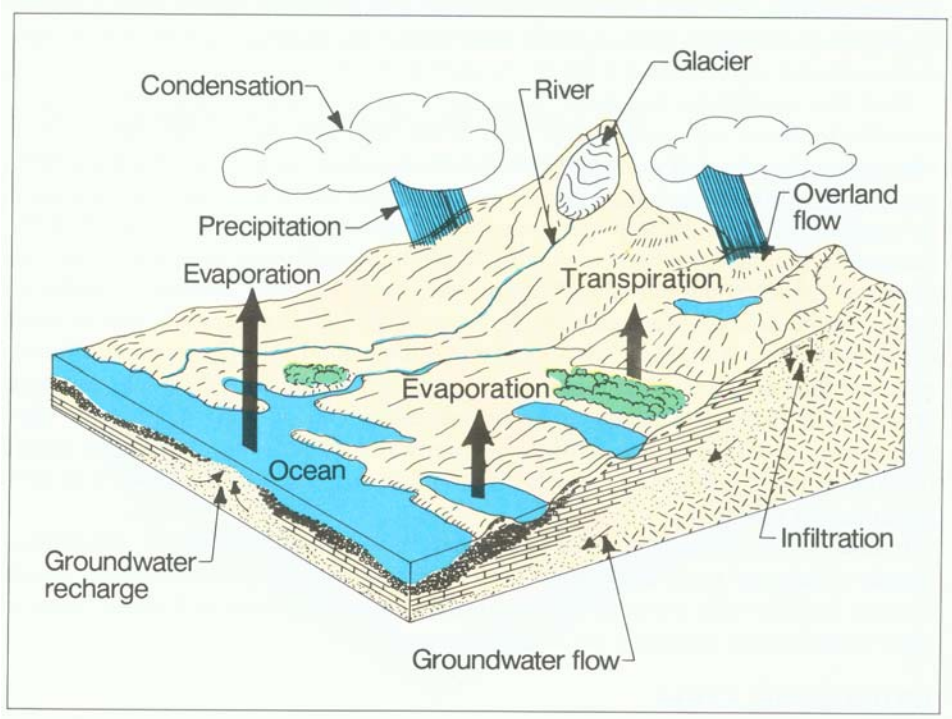


Figure 1. Water Cycle (from *Groundwater and Wells*, Driscoll, 1986)

Much of the water cycle is not easily observable; for example, it is difficult for an observer or resident to quantify the uptake of rainwater by plants, nor the evaporation of stream water. Therefore, another way of understanding water flow is by dividing it into three observable elements: water entering the ahupua`a, water within the ahupua`a, and water leaving the ahupua`a.

**Water Entering the Ahupua`a.** Fresh and salt water enter the ahupua`a through rain and the Pacific Ocean, respectively. Rainfall, particularly within upland areas at the Koolau pali, is the main source of fresh water. Rain is generally considered clean and pristine. Fresh water can also enter an ahupua`a through manmade diversions such as ditches from adjacent ahupua`a, as is the case with water diverted from Maunawili to Waimanalo, or from water supply lines, such as those between Windward Oahu and Honolulu. Fresh water can also be added to an ahupua`a through water supply lines fed from reservoirs. The Pacific Ocean is source of salt water entering the ahupua`a in Kailua Bay and into the estuaries at Oneawa Canal and Ka`elepulu Stream.

**Water Within the Ahupua`a.** Water within the ahupua`a includes groundwater, streams, canals, estuaries, and the ocean. Water within the ahupua`a also includes surface runoff during rain events and during ongoing urban activities such as car washing, irrigation, and landscaping. During heavy rains, surface runoff provides water to streams, ponds, and canals, but most often these surface water bodies are fed by groundwater from upland areas. This is demonstrated by continual water flow in streams even in the absence of rain events. Groundwater flows beneath the surface in soil layers called aquifers. Aquifers can be as shallow as at the surface (in the case of springs) to thousands of feet deep. Groundwater flow can be high in upland areas with steep topography (Koolau pali, Maunawili, Kapaa) or slow to stagnant in flat areas (Coconut Grove, Kailua Town, Kawai Nui Canal, and Enchanted Lake). Springs form an economically and ecologically important source of water in the ahupua`a. Historically, one of the main sources of drinking water in the Kailua ahupua`a was a spring adjacent to Ulu Po heiau, along the Pali Highway side of Kawai Nui Marsh; the spring still provides fresh water for kula (crops).

Water within the ahupua`a flows toward lower elevations. Water from uplands flows toward lowlands through streams or manmade canals, which then continue to flow toward marshes, lakes, wetlands, or the ocean. Groundwater flows toward streams or other topographic depressions. Note that the natural flow of water within an ahupua`a can be diverted through dams, embankments, pumping stations, or other diversions.

Groundwater composes the majority of water volume within the ahupua`a (not including the ocean). Groundwater can serve many purposes, depending on its availability, quality, and quantity. Groundwater within Oahu is managed by the Honolulu Board of Water Supply as a result of a comprehensive strategy for the island. Groundwater (and groundwater pumped to reservoirs) within Kailua and the surrounding ahupua`a is managed by the Board to help ensure that water is used where it is most needed, and water is often imported to or exported from one ahupua`a to another. (For more information on the history of the Board of Water Supply and its mission, see *www.hbws.org*.)

**Water Leaving the Ahupua`a.** Water leaves the ahupua`a through discharge to the ocean, evaporation, plant and animal uptake, and human uses such as drinking water consumption, industrial processes, or diversions to other ahupua`a. The main source of water leaving the Kailua ahupua`a is flow through the canals and streams to the ocean. Water also leaves the ahupua`a through the existing storm and sewer water systems maintained by the City and County of Honolulu. Community concerns regarding discharge of wastewater to Kailua Bay through sewer outfall systems was a primary factor in the Consent Decree with the City and County of Honolulu and led to the formation of the Kailua Bay Advisory Council (KBAC).

Minimizing water leaving the ahupua`a is a common goal of watershed management practices, promotes water conservation, and is consistent with historic Hawaiian water usage practices within the ahupua`a.

General Water Flow Processes

The flow of water is the common physical process within the waterway system. Water flow mechanics are governed by complex chemical, biological, and physical processes; however, flow can be described using basic concepts and principles we observe in daily activities. Figure 1 graphically demonstrates the processes identified below.

Rainwater flows from upland areas to lowland areas through surface water. Surface water seeks natural depressions or existing channels, thereby forming streams and ponds, like a spill on the floor finds cracks and holes. Surface water that travels across permeable soils percolates into the ground until it reaches an aquifer where it meets existing water, whereupon it stops flowing vertically and begins to flow along the water table in a more horizontal direction, similar to the change in flow direction when a waterfall meets a stream. Surface water is absorbed by permeable materials such as sands and gravels, like a spill on a carpet. Rain that lands on impermeable surfaces such as sidewalks, streets, or developed land, flows more readily to channels, storm drains, and natural streambeds instead of being absorbed into the underlying soil. When water flows along impermeable surfaces, it picks up sediments and other contaminants, just as water in the gutter picks up leaves and trash. Water flowing over impermeable surfaces is more likely to be transported out of the ahupua`a through streams and discharge to the ocean than if the water was absorbed into the soil and groundwater.

While flow in upland areas is governed by gravity seeking lower elevations, flow within lowlands is more heavily influenced by changes in water entering or leaving the system. For example, water flow in marshes, open canals, or estuaries is heavily influenced by storm events, changes in hydraulic conditions (such as opening a dike or embankment), well pumping activities, or tidal fluctuations.

Water Flow Within the Kailua Ahupua`a

This section describes the water flow within the Kailua ahupua`a. Figure 2, at the end of this summary, identifies specific Kailua waterway units discussed in this section.

Water flows along two major watershed basins within the Kailua ahupua`a: the Kawai Nui and Ka`elepulu systems. Both systems maintain common elements discussed above, such as upland areas that provide a water source through rainfall and finally discharge to the Pacific Ocean. However, historical changes to the natural water drainage patterns in each system have resulted in unique water quality issues and concerns within each system.

Kawai Nui System. The Kawai Nui system is composed of the following areas: Kawai Nui Uplands, Kawai Nui waterways including Kawai Nui Marsh and Oneawa Canal, and discharge to Kailua Bay. Rainfall within upland and lowland areas drains into Kawai Nui Marsh and Oneawa Canal. In the upland area, drainage is fairly well defined and understood as the water flow follows general topographic features and existing stream beds. Flow along the foothills of lower Maunawili and the upland areas surrounding the Kawai Nui Marsh, including Kapaa and foothills north of Oneawa Canal, also follows existing stream beds and topographic features. Fresh water springs within Kawai Nui Marsh also contribute to the water flow within the system.

Currently, all flow from the upland areas that accumulates within the Kawai Nui Marsh is diverted into the Oneawa Canal along the southern portion of the elevated dike. The dike was constructed by the U.S. Army Corps of Engineers to minimize flooding from Kawai Nui Marsh by diverting the flow into Oneawa Canal. The dike is an impermeable vertical surface that water cannot penetrate. This dike diverts groundwater and surface water from its natural and historical flow from Kawai Nui Marsh to Kawai Nui Canal (on the northern side of the dike) and then to Ka`elepulu Stream. As a result of the dike, water from Kawai Nui Marsh currently flows to Oneawa Canal, which flows to Kailua Bay and the

Pacific Ocean. Oneawa Canal and Kawai Nui Canal are not hydraulically connected as demonstrated by the difference in surface water elevations.

The estuary at the mouth of Oneawa Canal flows directly to the Pacific Ocean. Brackish water (a mixture of fresh water and sea water due to tidal influence) at the estuary mouth mixes with Kailua Bay sea water. Kailua Bay is connected with the Pacific Ocean through complex intertidal mixing and current flows.

**Ka`elepulu System.** The Ka`elepulu system consists of the Ka`elepulu hydrographic unit and shares boundaries with the Kawai Nui system and Kawai Nui and Hamakua Canals, and then discharges to Kailua Bay. Rainfall within the upland eastern slopes of Mt. Olomana and Ka Iwa Ridge drain into small tributaries that drain into Kawai Nui and Hamakua Canal, Ka`elepulu Stream, and Enchanted Lake. Unlike Oneawa Canal, which has direct interaction with Kailua Bay, the lowermost drainage for these water bodies, Ka`elepulu Stream, does not have surface water interaction with Kailua Bay due to the presence of a sandbar at shoreline. The stream is hydraulically connected to the bay through tidal influence; however, the amount of water flow is minimal. Since surface water flow is minimal between Kailua Bay and the Ka`elepulu system, water remains relatively stagnant (low flow) in the absence of storm events or diversions (opening of sand bar). Constant tidal influence on the system has resulted in brackish water throughout Ka`elepulu Stream and Enchanted Lake. Stagnant water is observed from the head of Kawai Nui Canal to Enchanted Lake to the mouth of Ka`elepulu Stream. As discussed above, the Kawai Nui Canal historically provided flow from Kawai Nui Marsh into the Ka`elepulu system. As a result of the impermeable dike between Kawai Nui Marsh and Oneawa Canal and Kawai Nui Canal, there is little to no hydraulic interaction or flow between the systems.

Water Flow Regimes Between the Systems. Surface runoff attributed to rainfall and manmade processes within the Coconut Grove and Kailua Town areas contribute to water quality issues in Kawai Nui and Ka`elepulu systems. Surface and subsurface water within this area flow toward three different water bodies: Oneawa Canal, Kawai Nui and Hamakua Canals, and the Ka`elepulu system. Although distinct surface flow areas can be identified, water quality issues and concerns, and viable cleanup alternatives may be the same within these lowland areas. For this reason the area is identified as its own waterway unit that contributes to water quality in the three aforementioned water bodies.

Lanikai, although not between Kawai Nui and Ka`elepulu, makes up its own watershed basin and is not affected by surface runoff, groundwater, or stream flow from the other systems. Water within Lanikai also flows to Kailua Bay and the Pacific Ocean.

General Terms

*Ahupua`a:* A Hawaiian term for land units generally from sea to mountains used by chiefs and their people to help manage water resources and provide a share of food, supplies, and materials. The units were based on land units but also impacted by cultural and economic factors. Ahupua`a is geographically similar to a watershed; however, it can extend beyond the natural bounds of a watershed based on agricultural or economic practices. The Kailua ahupua`a encompasses the entire waterway system from the ridges of the Koolau pali, Kawai Nui Marsh, the canals and streams, lakes and ponds, groundwater, beaches, bay, ocean, and all land between. The boundary of the Kailua ahupua`a is shown on Figure 2.

Aquifer: Geologic unit containing groundwater

Brackish: A mixture of fresh and sea water

Estuary: The mouth of a river or stream that is affected by tides where fresh water mixes with sea water.

Groundwater: Measurable water found within subsurface soils.

Hydraulic: Pertaining to the movement of water.

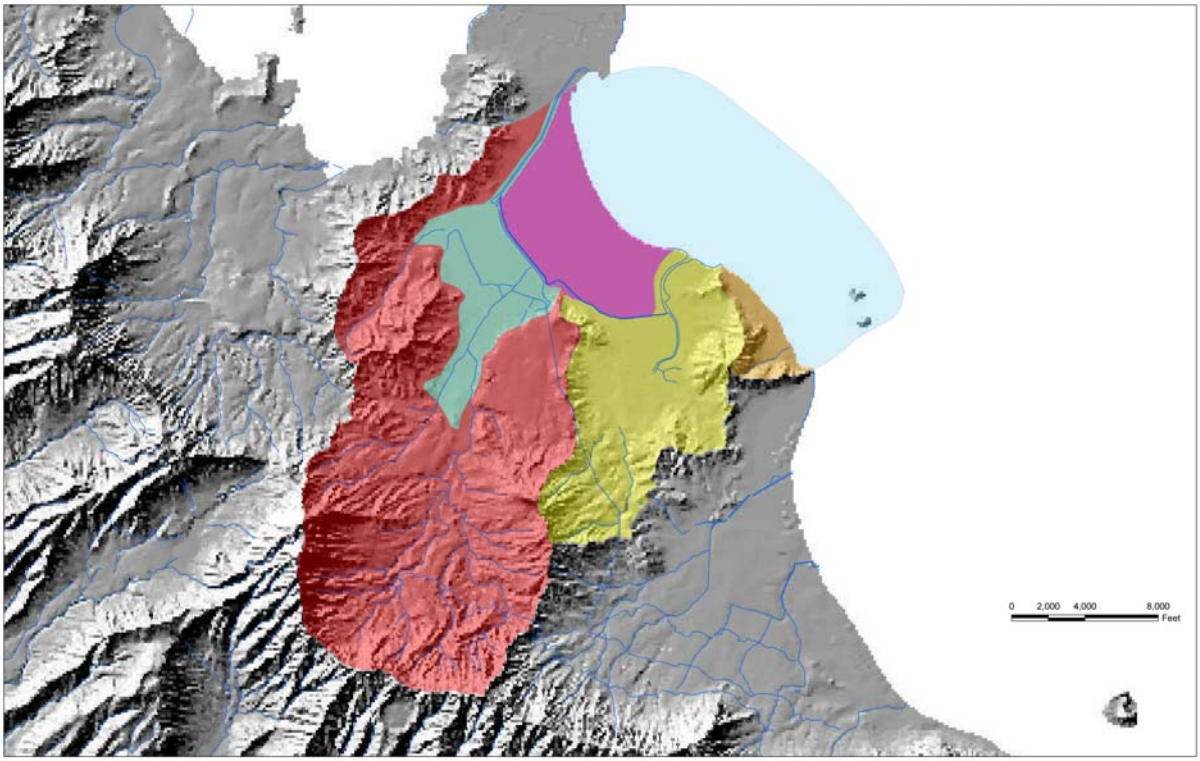
Hydrogeology: The study of groundwater.

Hydrology: The study of surface waters.

Kailua Waterway Units: Groupings of land and water bodies within the Kailua ahupua`a containing distinct components of the watershed drainage system. The units are solely intended to facilitate the discussion of common water quality issues and viable solutions for the Kailua Waterways Improvement Program.

Watershed: A geographic area, commonly a basin, where all land and water areas drain or flow toward a common water source at a lower elevation, such as a stream, river, lake, or ocean.

Figure 2. Kailua Ahupua`a and Waterway Units



Legend

- Kawai Nui Uplands: Source areas for Kawai Nui Marsh and Oneawa Canal
- Kawai Nui Waterways: Kawai Nui Marsh and Oneawa Canal
- Kailua Town and Canals: Source areas for Kawai Nui and Hamakua Canals and surface runoff to Kailua Beach and Kailua Bay
- Ka`elepulu System: Upland and surface runoff source areas and water bodies within Ka`elepulu Stream, Enchanted Lake, upland areas.
- Lanikai: Upland and surface runoff source areas to Lanikai Beach and Kailua Bay
- Kailua Bay: Kailua and Lanikai Beaches and Kailua Bay